The Standard Maze-III Procedure

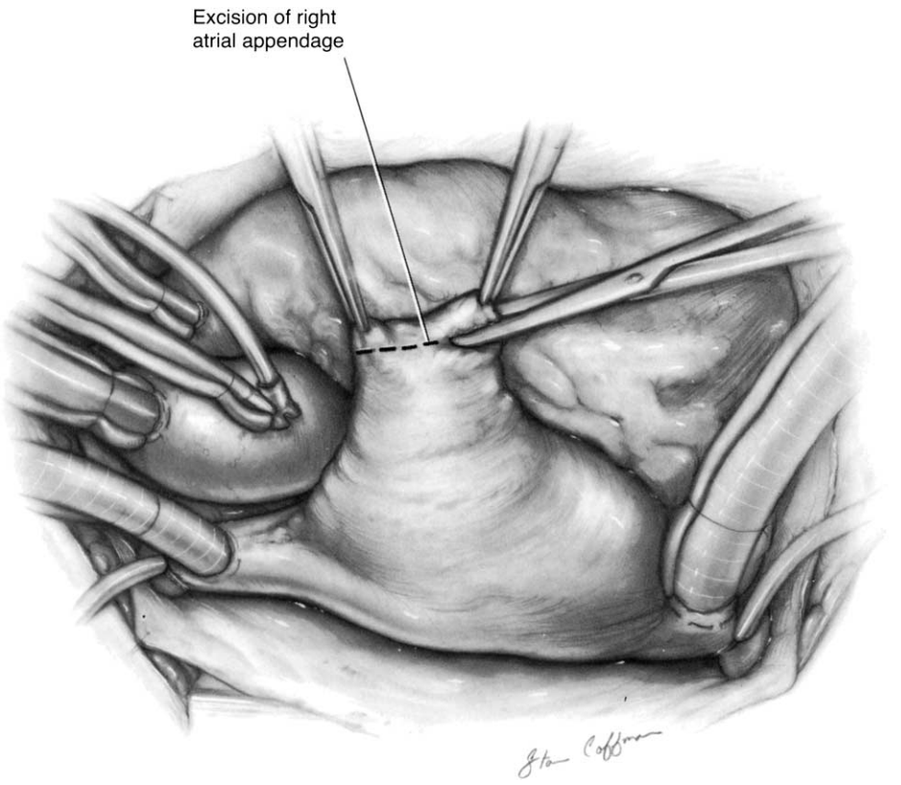
James L. Cox

The original Maze procedure (Maze-I) was introduced clinically in September 1987. Although this technique was extremely effective in controlling atrial fibrillation, it resulted in two unforseen problems:

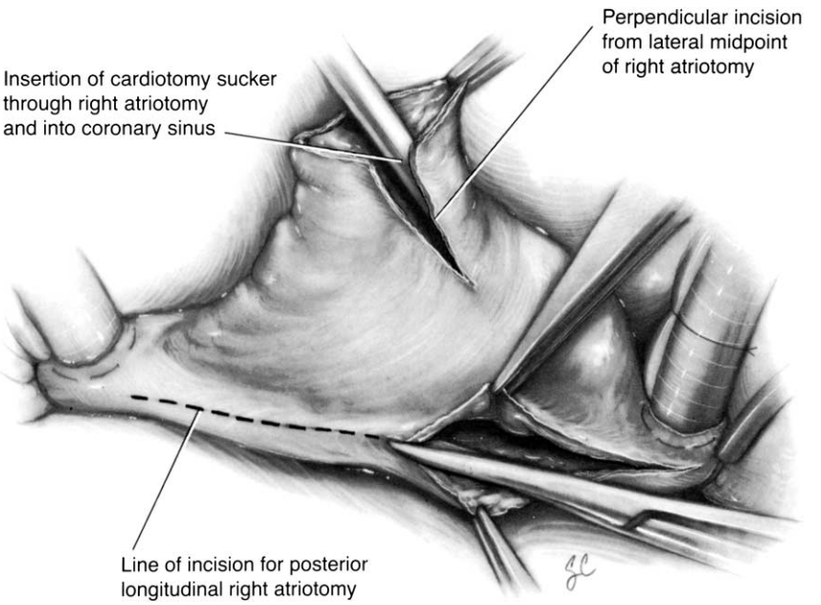
1. Chronotropic inadequacy of the sinoatrial (SA) node. Many patients were unable to develop a sinus tachycardia rate commensurate with the level of their physical activity postoperatively because one of the incisions was positioned in the ''sinus-tachycardia region'' of the SA node, immediately anterior to the orifice of the superior vena cava (SVC).

2. Prolonged intra-atrial conduction delay. This resulted in the sinus node impulse arriving in the left atrium at the same time it arrived in the left ventricle. This, in turn, resulted in apparent absence of left atrial contraction postoperatively because it was contracting at the same time as the left ventricle.

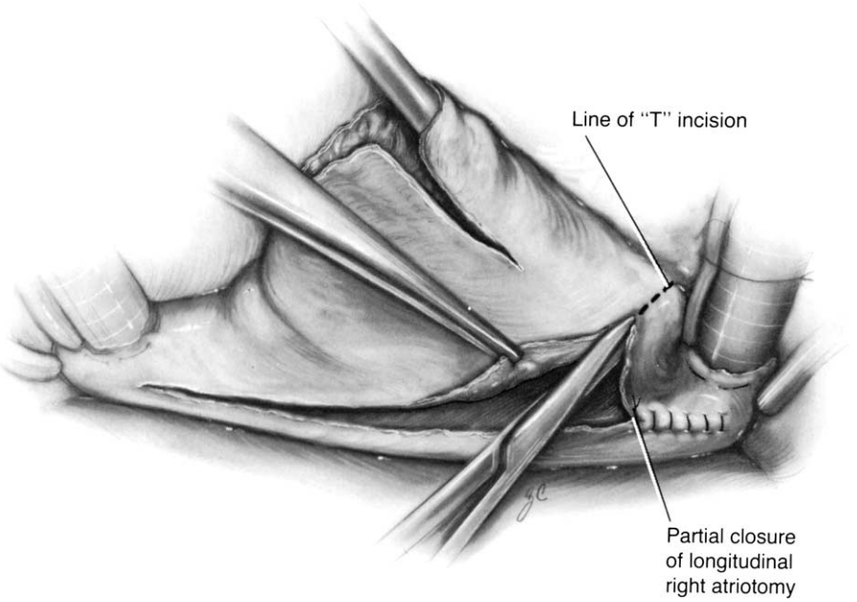
Because of these problems in the first 32 patients, the Maze-I procedure was modified to the Maze-II procedure in the next 15 patients. This technique was equally effective in controlling atrial fibrillation but proved to be extremely difficult to perform technically because of the frequent necessity for transection of the SVC. As a result, the Maze-II was further modified to the Maze-III procedure, which is depicted in the following figures. This technique has been in continuous use since April 1992 and, therefore, has been used in the vast majority of patients in our series. Both of the problems mentioned above were abolished by this last modification in technique.



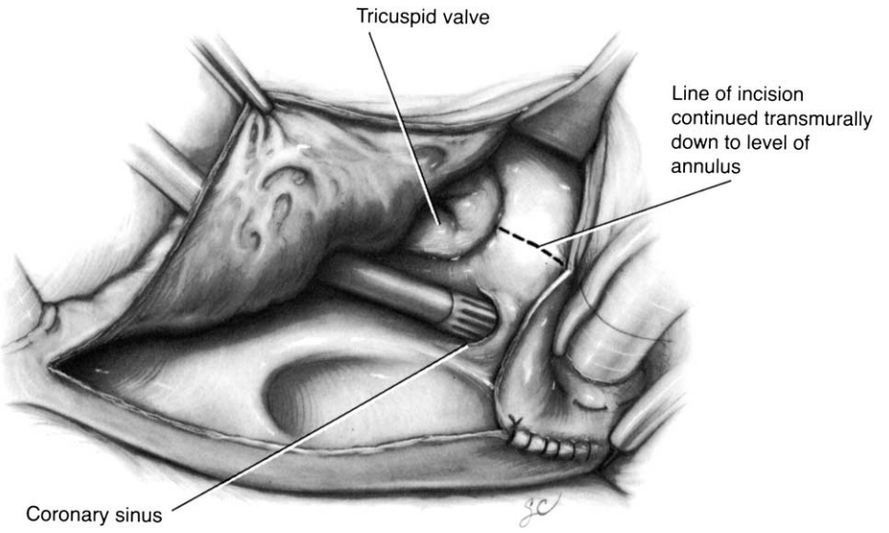
1 After total cardiopulmonary bypass is established and the caval tapes are secured, the right atrial appendage is excised. At least 2 cm of visible atrial muscle should be preserved between the superior end of the excised appendage (*dashed line*) and the orifice of the superior vena cava (SVC). Note that the SVC is cannulated directly approximately 2 cm above the right atrium and that the inferior vena cava also is cannulated low. A pulmonary artery vent is shown in position, as is the combined cardioplegia infusion-aortic vent in the ascending aorta. Reprinted with permission.[1]



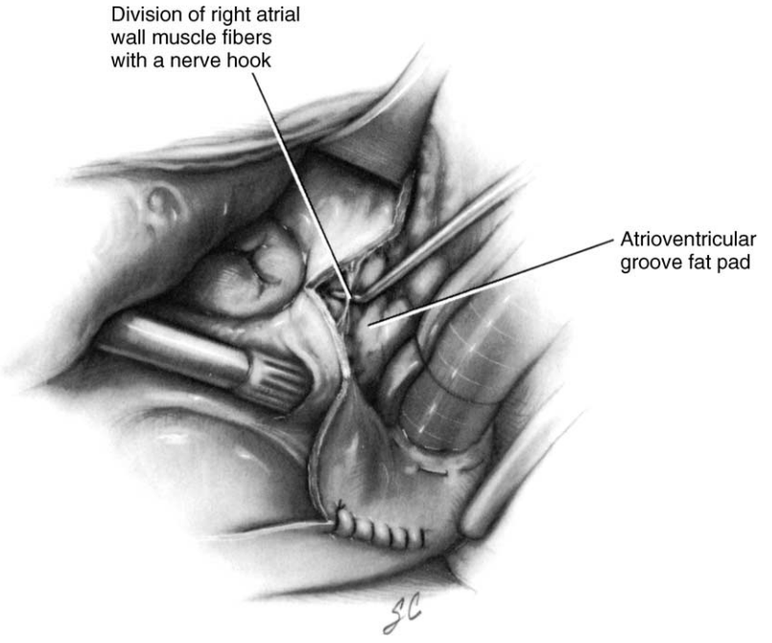
2 A lateral incision, parallel to the right atrioventricular groove, is placed from the base of the excised atrial appendage toward the inferior vena cava (IVC), leaving 5 to 6 cm of right atrial free wall between the lower end of the incision and the IVC cannula. A posterior longitudinal incision is then placed from well into the SVC (*dashed line*) to well into the IVC. It is helpful to place a cardiotomy sucker into the opening of the coronary sinus via the atrial appendage during placement of the posterior longitudinal incision. Reprinted with permission.[1]



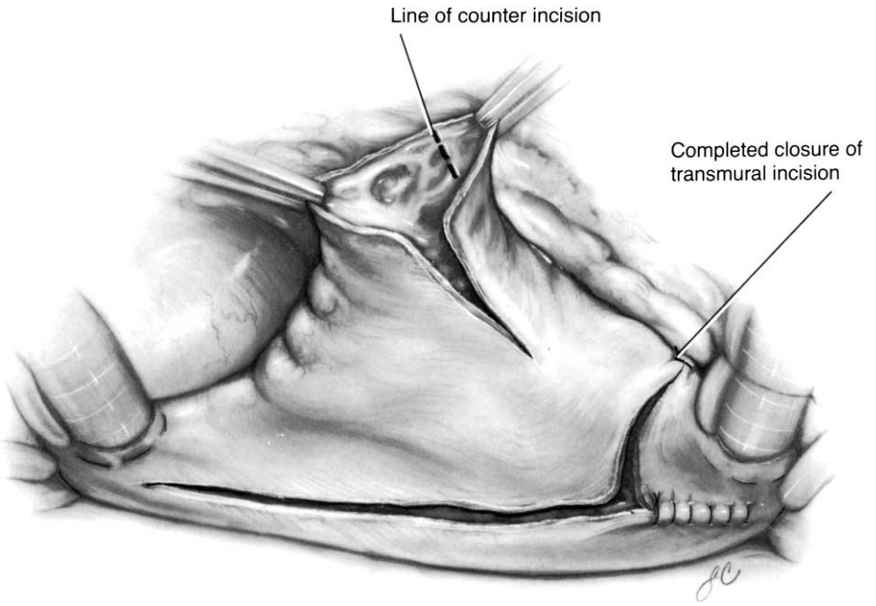
3 The lower portion of the posterior longitudinal incision is closed immediately to prevent inadvertent tearing and extension of the incision into the IVC during later retraction. The incision usually is closed to the level of the top of the IVC cannula. A T incision is then made from this point across the lower right atrial free wall approximately 1 cm above the IVC cannula. The T incision is extended to the top of the right atrioventricular groove (*dashed line*). The remainder of the incision, extending to the tricuspid valve annulus, must be made from inside the right atrium. Reprinted with permission.[1]



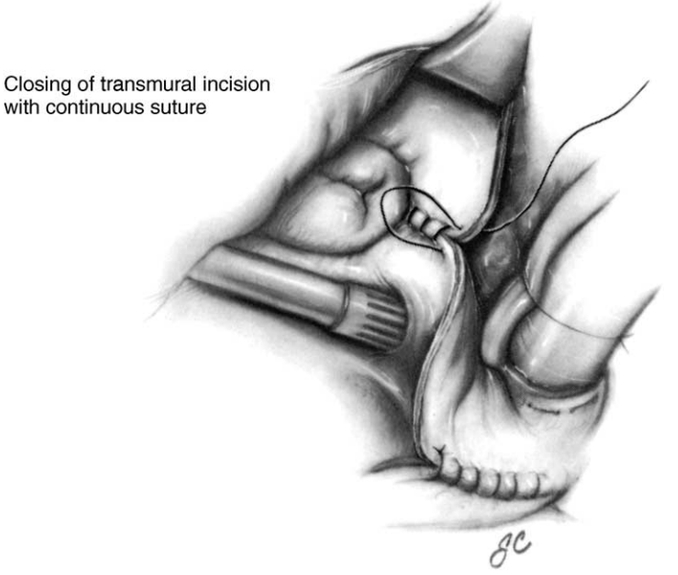
4 The right atrial free wall is retracted anteriorly and superiorly. The dashed line shows the planned extension of the T incision to the tricuspid annulus. This continues to be a transmural atriotomy, but underlying this portion of the incision is the fat pad of the right atrioventricular groove that harbors the right coronary artery. Therefore, this portion of the incision must be made with care. Once the atrial wall has been divided transmurally, the fat in the atrioventricular groove is visible. Reprinted with permission.[1]



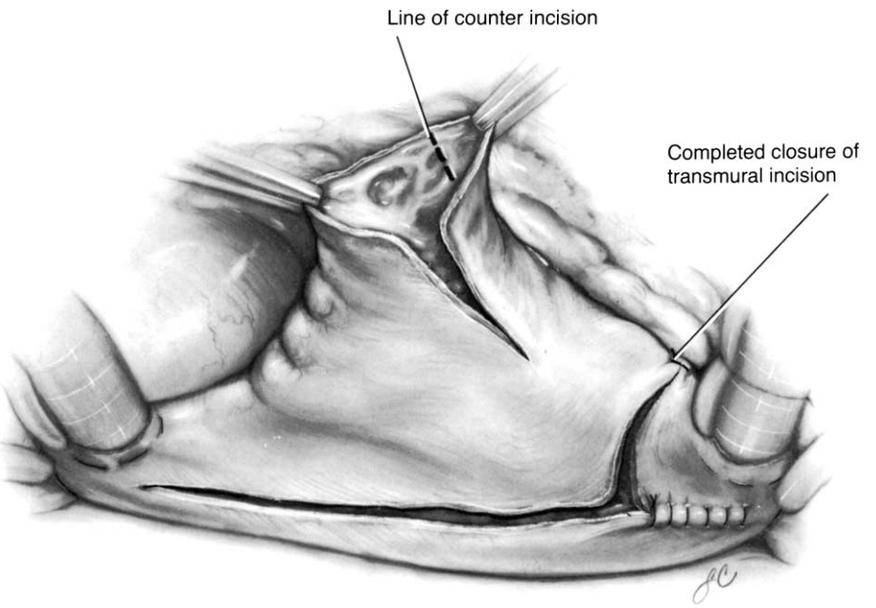
5 It is essential to divide all atrial myocardial fibers traversing this portion of the T incision using either a knife or a nerve hook. Reprinted with permission.[1]



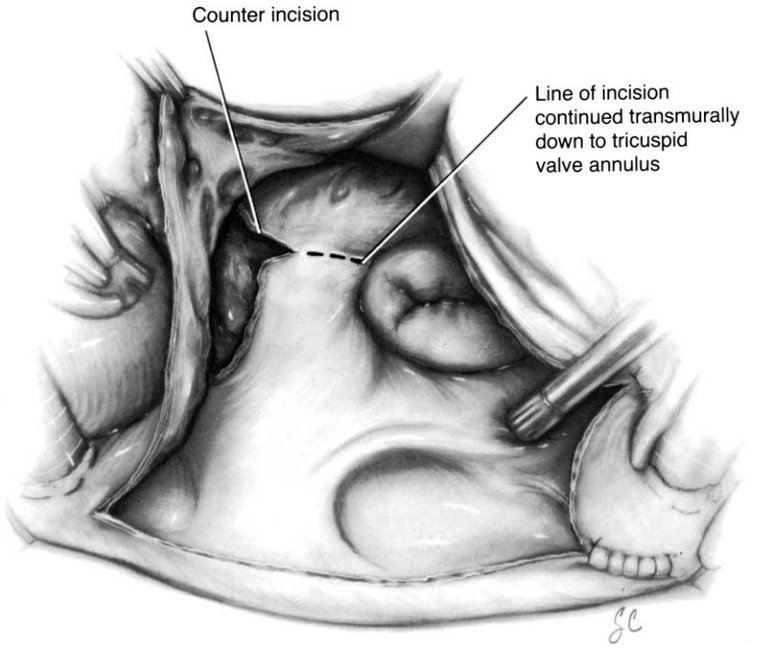
6 A cryolesion is placed at the tricuspid end of the T incision to be certain that no remaining fibers traverse the incision at the level of the tricuspid valve annulus. A 3-mm cryoprobe is applied for 2 minutes at −60°C. Reprinted with permission.[1]



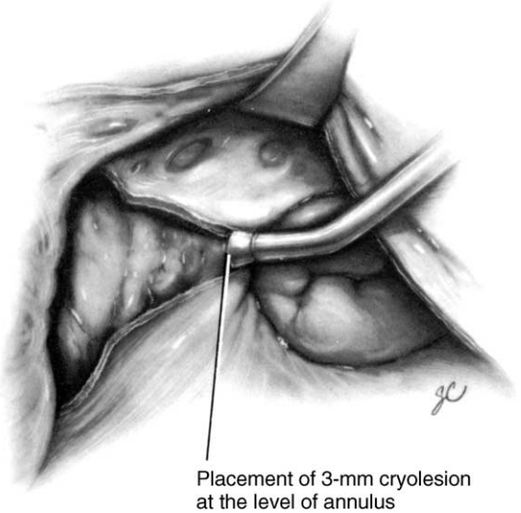
7 The tricuspid end of the T incision is closed to the level of the top of the atrioventricular groove. The remainder of the incision is left unclosed in order to attain better surgical exposure during the remainder of the procedure. Reprinted with permission.[1]



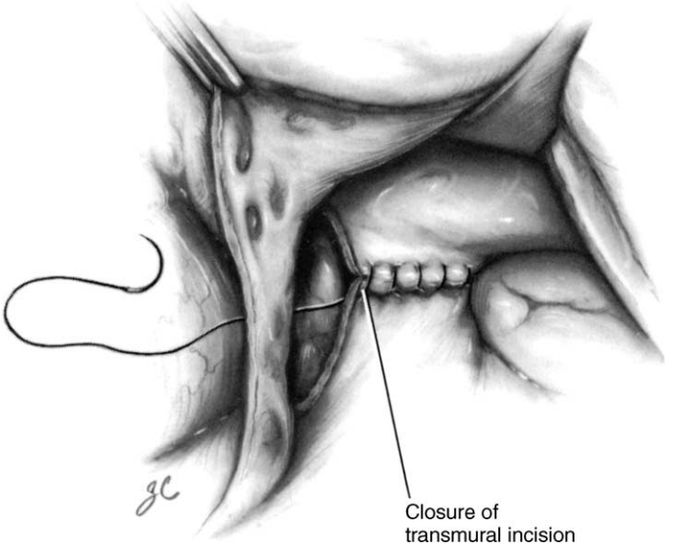
8 Once the lower ends of the posterior longitudinal incision and the T incision have been closed, the anterior right atrial counter incision is performed beginning at the anteromedial border of the excised right atrial appendage (*dashed line*). This incision extends to the anteromedial tricuspid valve annulus, and once begun it is easier to complete from within the right atrium. Reprinted with permission.[1]



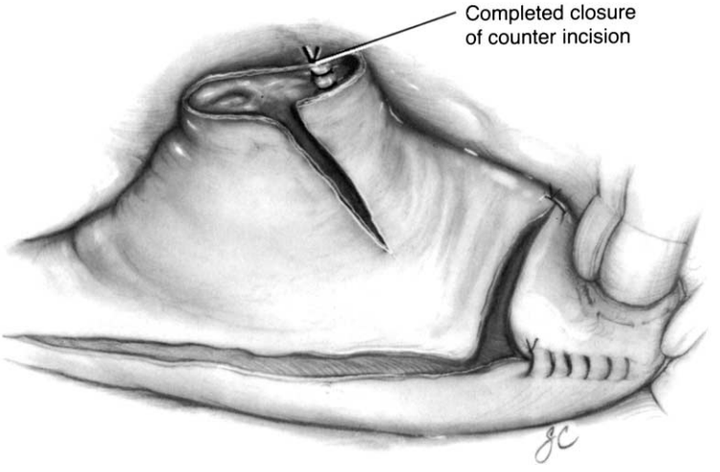
9 The right atrial free wall is retracted anteriorly and superiorly to expose the anteromedial portion of the tricuspid valve annulus and the upper portion of the counter incision that has been started from outside the right atrium. The dashed line shows the planned extension of this counter incision to the tricuspid valve annulus. Reprinted with permission.[1]



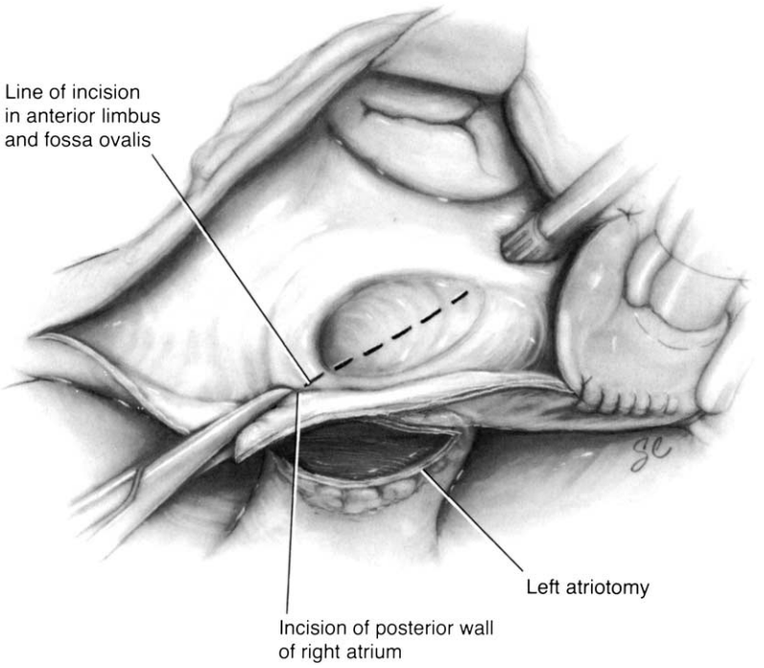
10 The counter incision is transmural, but care must be taken in dividing the final myocardial fibers because the right atrioventricular groove fat pad lies immediately beneath the incision. This portion of the right atrioventricular groove corresponds to the anterior septal space. In this case, the incision is approximately 2 to 3 cm anterior to the atrioventricular (AV) node—His bundle complex. The right coronary artery usually has not joined the right atrioventricular groove at this point, although anatomic variations exist. A 3-mm cryolesion is also placed at the tricuspid end of this incision to ensure its completion. This is the final right atrial incision. Reprinted with permission.[1]



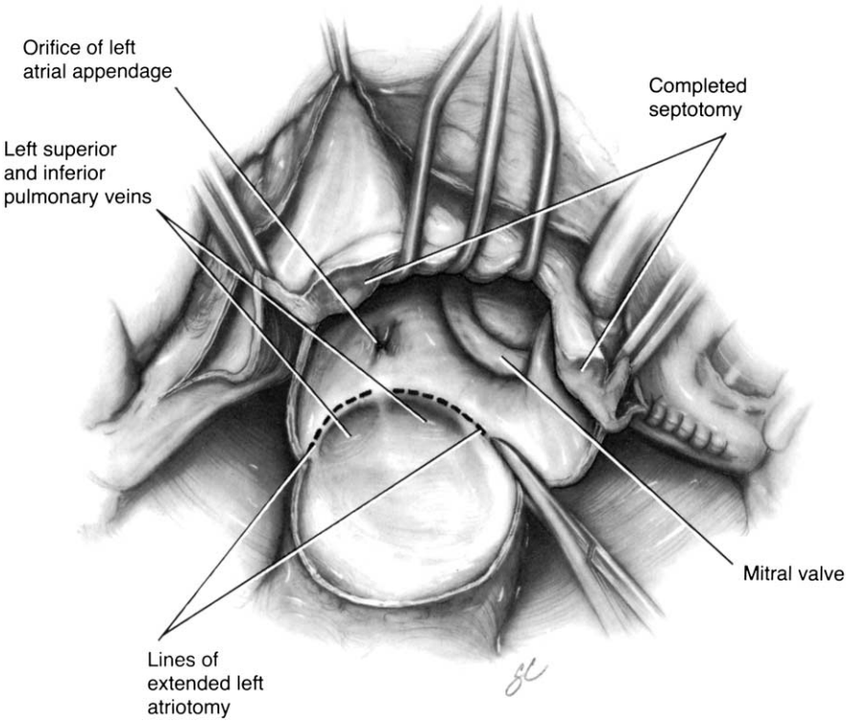
11 The entire counter incision is closed to the base of the excised atrial appendage. Reprinted with permission.[1]



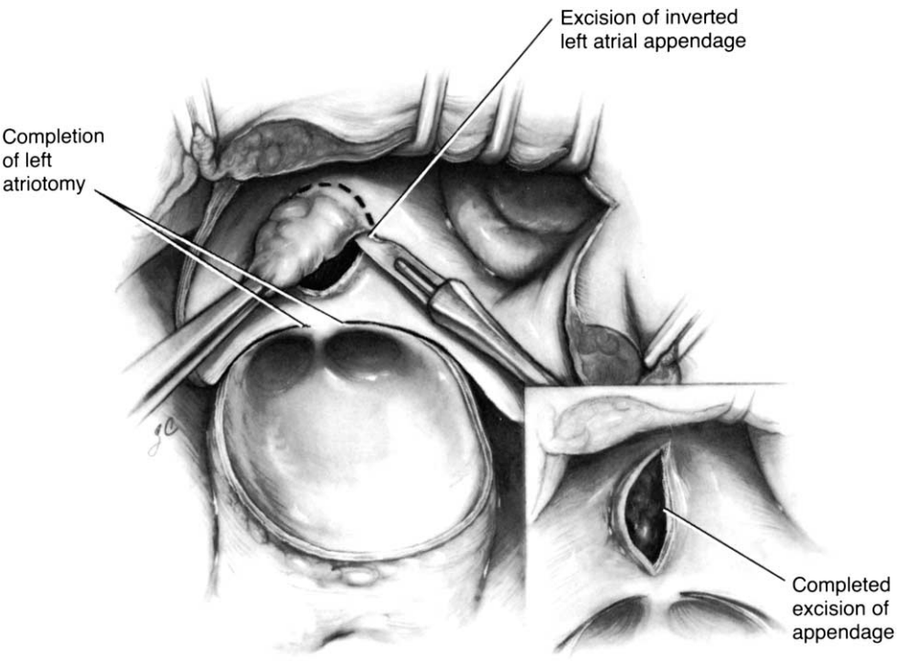
12 Once the anteromedial counter incision has been closed, the remaining right atrial incisions are left unclosed until the left atrial procedure has been completed. Reprinted with permission.[1]



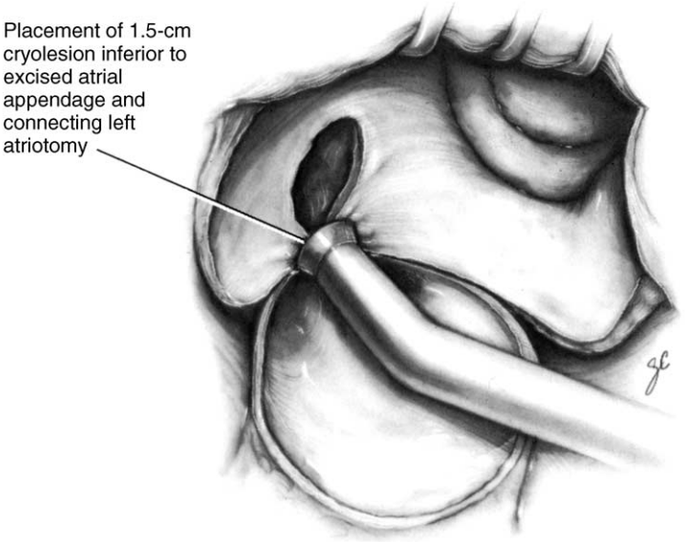
13 A standard left atriotomy is performed in the interatrial groove, its lower end being extended around the lower lip of the orifice of the right inferior pulmonary vein. The atrial septum is then divided beginning 2 to 3 cm below the orifice of the superior vena cava, traversing the anterior limbus of the fossa ovalis, and then traversing the fossa ovalis itself (*dashed line*). This septal incision should be slanted in the general direction of the opening of the coronary sinus, but it is absolutely essential to terminate it at the bottom of the thin portion of the fossa ovalis. Reprinted with permission.[1]



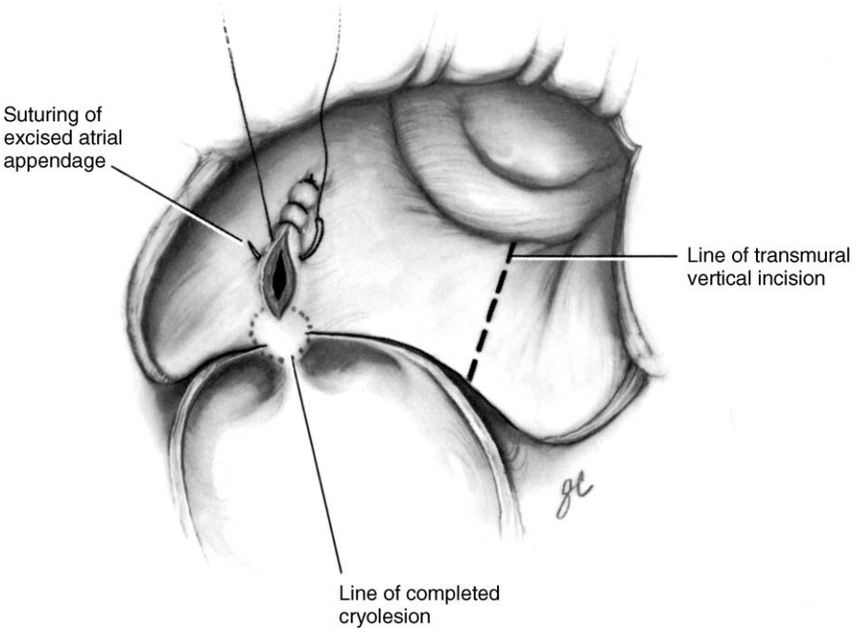
14 The atrial septum is retracted for optimal exposure of the left atrium, mitral valve, left pulmonary veins, and orifice of the left atrial appendage. The standard left atriotomy is extended *inferiorly* across the posterior left atrial free wall between the mitral valve and the orifices of the inferior pulmonary veins. Likewise, the *superior* portion of the standard left atriotomy is extended around the lip of the left superior pulmonary vein orifice. Before the two ends of this pulmonary vein isolation incision are joined, the left atrial appendage is excised. Reprinted with permission.[1]



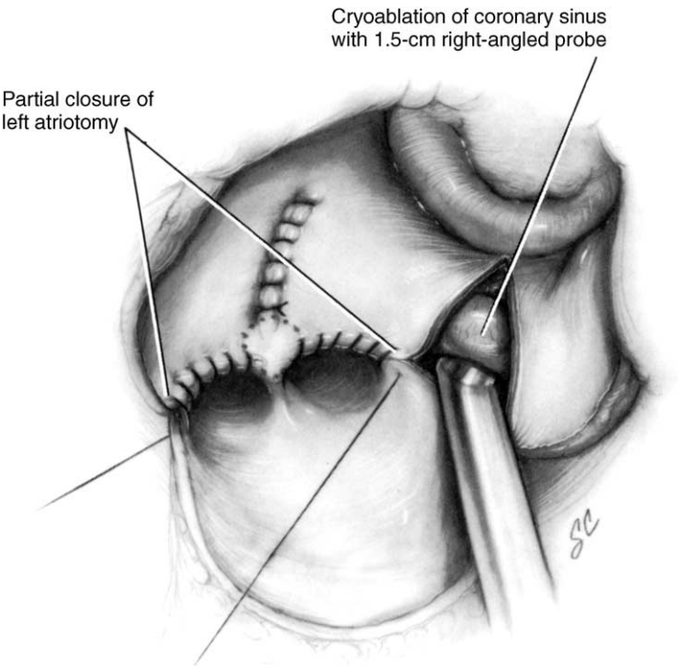
15 The left atrial appendage is inverted and amputated at its base. The base of the appendage to the right, as viewed by the surgeon in this orientation, must be approached with special care because the circumflex coronary artery may course very near to this portion of the incision. Once the appendage is excised, a small bridge of tissue remains between the appendage amputation site and the two ends of the pulmonary vein encircling incision (*inset*). This bridge of tissue can be divided and closed with sutures, or it can be left intact and cryoablated. Reprinted with permission.[1]



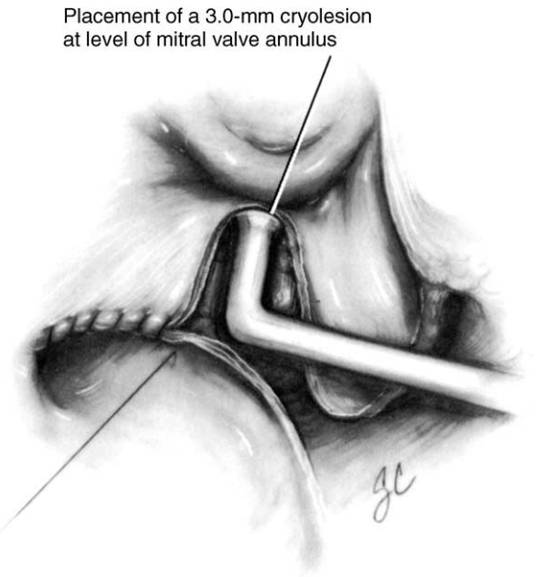
16 A 1.5-cm cryoprobe is applied to the bridge of tissue for 2 minutes at −60°C. The isolation incision of the pulmonary vein is much easier to close if this tissue bridge is left intact rather than surgically divided. Reprinted with permission.[1]



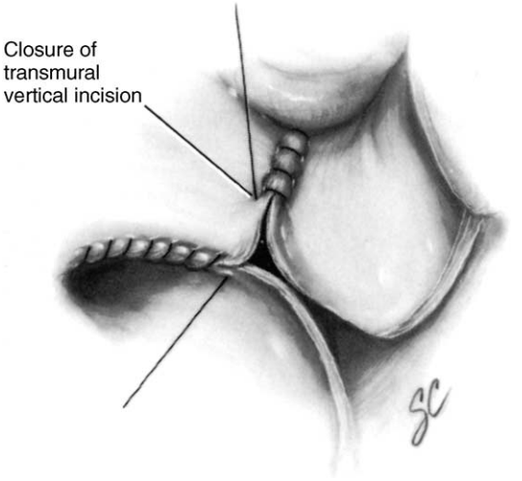
17 After the cryolesion is completed (*dotted circle*), the site of the appendage amputation is closed. The dashed line represents the site of the final incision, a posterior vertical left atriotomy that extends from the pulmonary vein isolation incision to the mitral valve annulus. Reprinted with permission.[1]



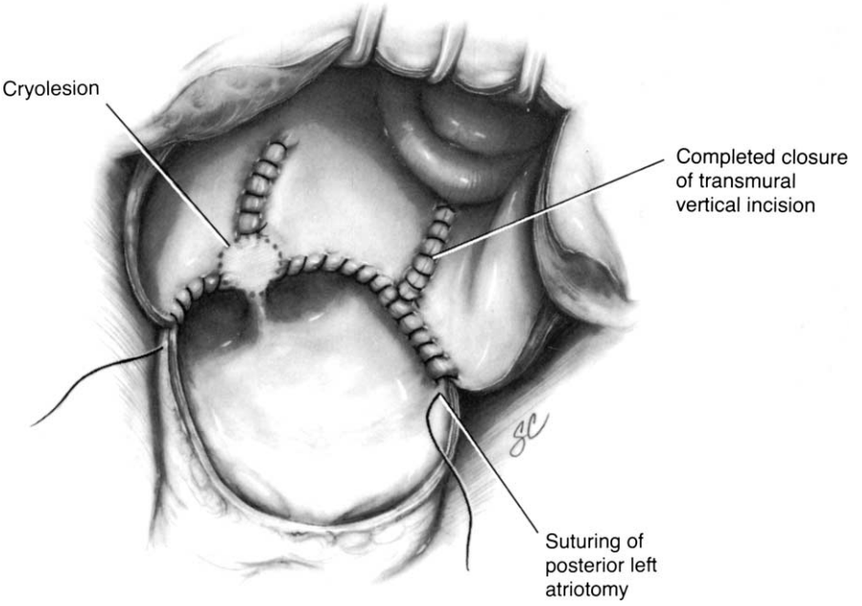
18 Once the posterior vertical incision is made and all visible atrial myocardial fibers spanning the fat pad of the underlying atrioventricular groove have been divided, the coronary sinus is subjected to transmural cryothermia at −60°C for 3 minutes. Care is taken to avoid applying cryosurgery to the circumflex coronary artery. In addition, if retrograde cardioplegia is used, the cannula should be removed during this portion of the procedure. Reprinted with permission.[1]



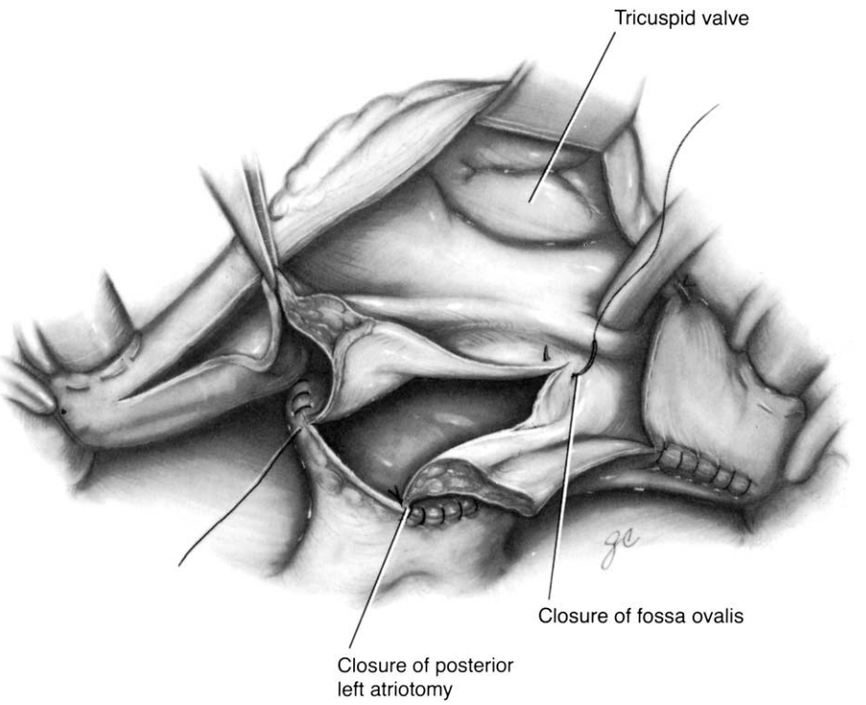
19 A 3-mm cryolesion is placed at the lower end of the incision adjacent to the mitral valve annulus. Reprinted with permission.[1]



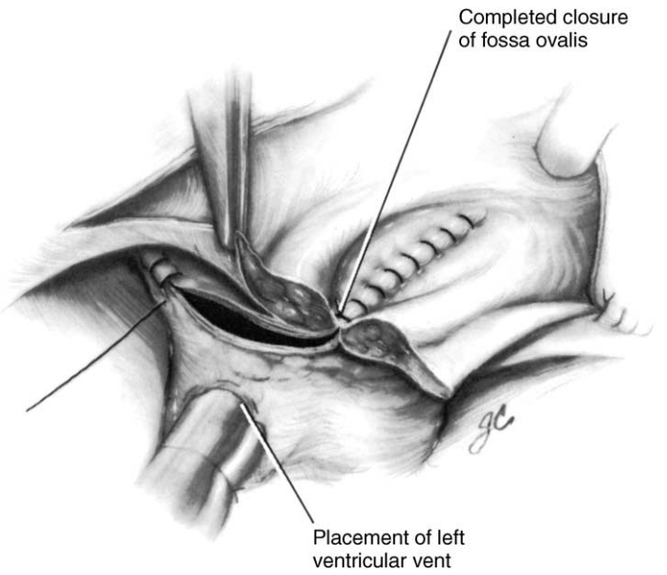
20 The posterior vertical left atriotomy is closed. Reprinted with permission.[1]



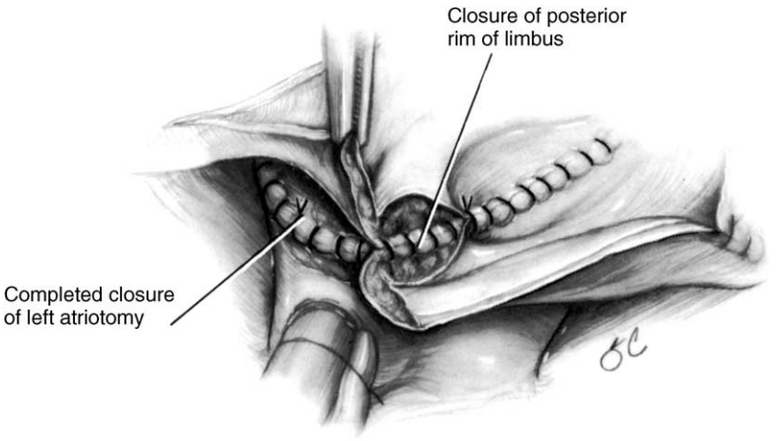
21 The lower portion of the pulmonary vein isolation incision is closed across the posteroinferior free wall of the left atrium. Reprinted with permission.[1]



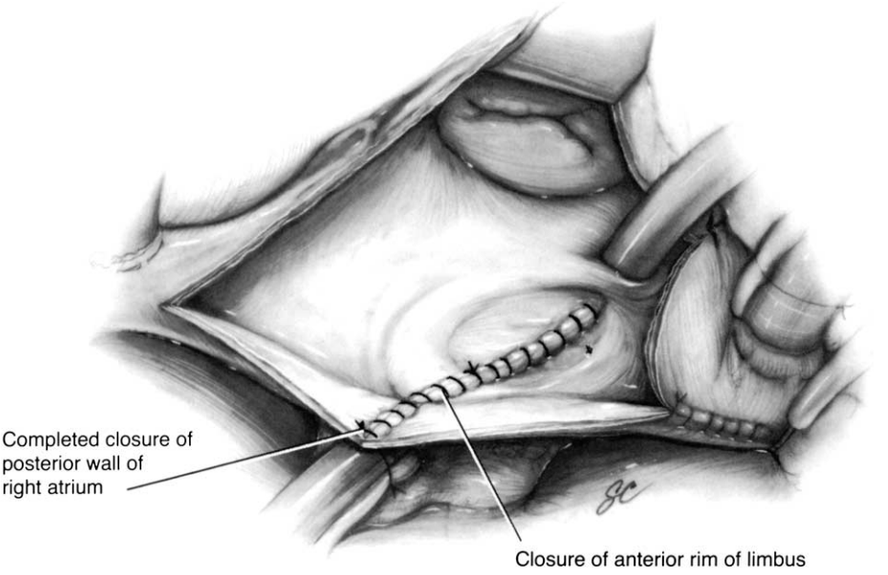
22 Once the lower portion of the pulmonary vein isolation incision has been closed to the level of the atrial septum, the incision again resembles a standard atriotomy in the interatrial groove. At this point, the septal incision is closed beginning at its lower end. A retrograde cardioplegia cannula is shown in the os of the coronary sinus. Reprinted with permission.[1]



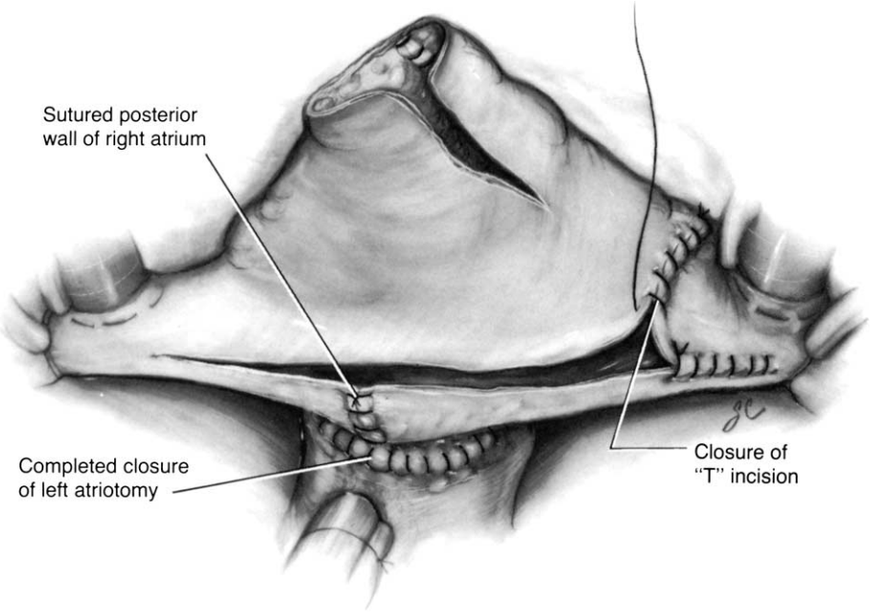
23 The thin portion of the fossa ovalis is closed up to the inferior margin of the anterior limbus. Reprinted with permission.[1]



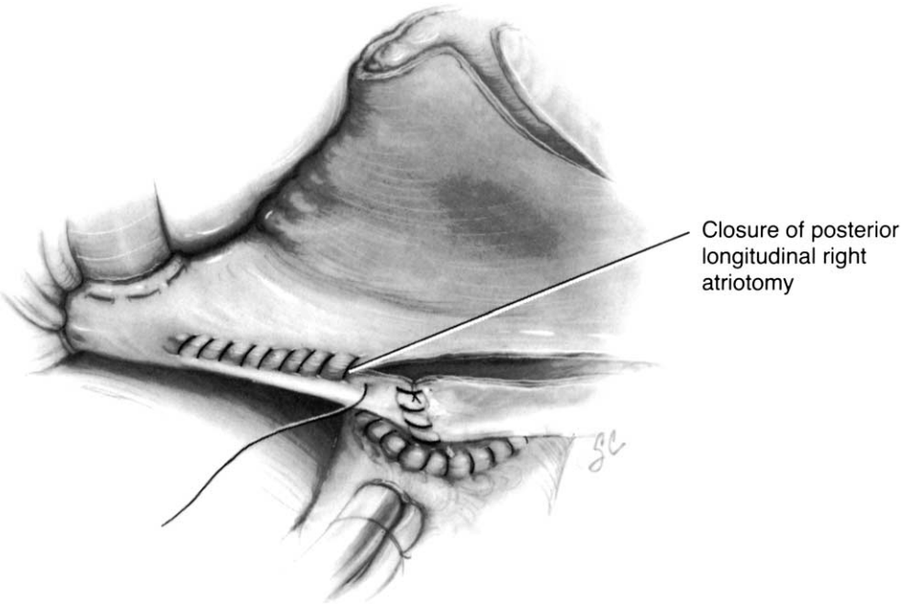
24 The left atrial side of the limbus of the fossa ovalis is closed in continuity with the remainder of the superior left atriotomy. Reprinted with permission.[1]



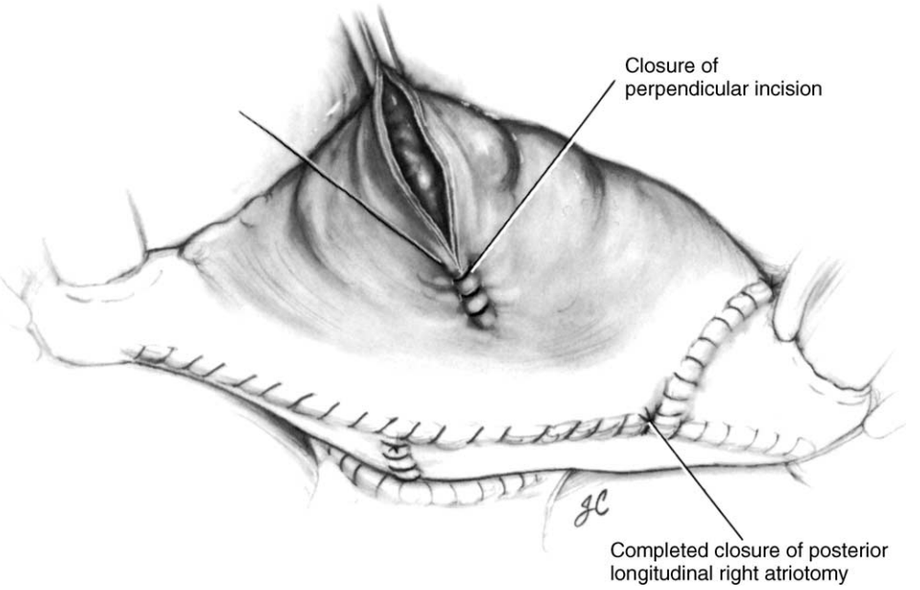
25 The right side of the limbus of the fossa ovalis is closed in continuity with the portion of the posterior right atrial free wall that is medial to the posterior longitudinal right atriotomy. Reprinted with permission.[1]



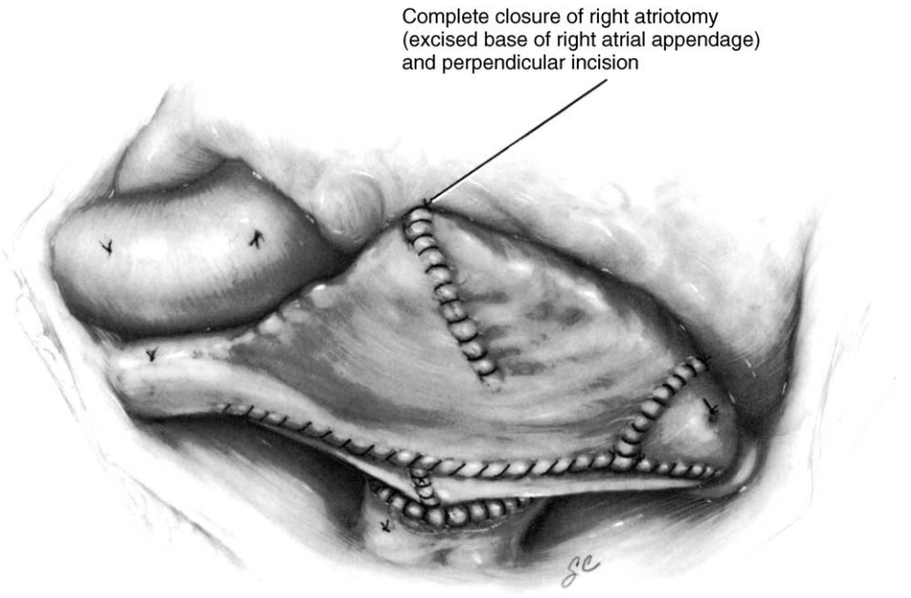
26 The remainder of the right atrial T incision is closed. Reprinted with permission.[1]



27 The remainder of the posterior longitudinal right atriotomy is closed. Reprinted with permission.[1]



28 The lateral right atriotomy and the site of the amputated right atrial appendage are closed in continuity from a lateral to a medial direction. Reprinted with permission.[1]



29 Appearance of the completed Maze III procedure. Reprinted with permission.[1]

Summary

A total of 299 patients have undergone the Maze-III procedure in our unit. Thirty-eight percent of all patients experienced temporary perioperative atrial fibrillation within the first 3 months after surgery. These early postoperative arrhythmias invariably responded to routine medical therapy, and they had no correlation with long-term results of the surgery. Overall, only 4 of 346 patients who have had any type of Maze procedure still have atrial fibrillation, a failure rate of 1.2%.

One of the commonly repeated misconceptions regarding the Maze procedure is that the surgery itself damages the sinus node mechanism and causes patients to need pacemakers postoperatively. Overall, only 15% of the patients required new pacemakers after surgery. Indeed, 123 patients who underwent the Maze procedure alone were documented to have normal sinus node function preoperatively, and not one of those patients needed a permanent pacemaker after the Maze procedure. Thus, it is clear that *the Maze procedure itself does not cause the patient to need a pacemaker after surgery*.

Another common misconception is that the atria do not function after the Maze procedure. In our series, all patients were documented to have both right atrial and left atrial transport function in the immediate postoperative period that contributed to forward cardiac output. On late follow-up evaluation, various tests were used to determine whether or not either or both atria were contracting. These tests included dynamic MRI scanning, AV pacing versus ventricular pacing, transthoracic echocardiography, and transesophageal echocardiography. Using one or more of these tests, 98% of patients were documented to have right atrial transport function and 93% of patients were documented to have left atrial transport function after the Maze-III procedure.

REFERENCES

1. Cox JL: The Maze III procedure for treatment of atrial fibrillation, in Sabiston Jr DC (ed): Atlas of Cardiothoracic Surgery. Philadelphia, PA, Saunders, 1995, pp 460-475

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